# MIMESIS : a physically-based software for computer animation and dynamic visual arts

Annie Luciani

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## A physically-based software for computer animation and dynamic visual arts

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Abstract

Conventional computer animation design movements by giving 2D or 3D key-frames and interpolating the motion between the key-frames. Another way consists in applying time-evolution fonctions onto specific parameters of 2D and 3D objects (positions, sizes, déformations of shapes, colors ...). In all these cases, softwares is geometrically and cinematically oriented, in the sense that the user designs first the morphology of the object to be animated and secondly, he applies a cinematic to this object.

By these means, deeply pertinent motion features can be performed : changing in dynamics, various dynamics of collisions, correlated deformations, complex deformations and transformations. Physical-based models allow the user to achieve complex and well-controled deformations : modelling rigidities, interactions (collisions, frictions, adherences), deformations (fluids, pastes, tissues ...), complex evolutive phenomena such as turbulences, avalanches, metabolic effects ... In addition, Physically-based models allow the user to animate his virtual objects by means of gestural manipulation of the virtual objects and then to obtain introduce real time expressivity in the motions. Then, these technics introduce a deep breakthrough in Computer Animation and Dynamical Visual Arts : the introduction of the instrumental control of visual evolutions, such as in music. Consequently, the creative process is fundamentally transformed : first the artist performs his complex motions and secondly he matches theses motion through various visual representations. Motions, gestures, intrumental relationship are placed at the first level of artistic design, opening a true computer cinetic visual art.

We will present a computer tool, MIMESIS, developped by ACROE in Grenoble, completely based on the modeling of virtual objects by means of "modular physics", and animated sequences resulting of scientific and artictic works with this tool. Thanks to the same basic concepts between MIMESIS and GENESIS, the ACROE software to create music by means of physically-based modelling, we present also the relationship between these two software, having the project to propose a tool which allows to design music and visual motion and animation in a strongly closed way.

• the concept of simulation,

• the difference between "cinematics" and "dynamics".

When one says "simulation", we usually understand "simulation" in the sense used by physicists ; that is, "a copy of the real matter". It is not my understanding.

• By "simulation", I understand the process of creating a virtual cause of a given or desired dynamic phenomenon, even if this cause is not similar to a real cause.

• This virtual cause can be expressed, or modelled, or metaphorized, by the generic rules of dynamic systems, such as : inertia, elasticity, viscosity, resistance to displacements and deformations, forces, energy ..., and so, whatever the dynamic phenomenon is. These terms define the vocabulary of "dynamics".

I will show you in the video different exemples of dynamic effects produced by dynamic simulations.

• Instead of these dynamic elements, the elements of the explicite description of motion used in conventional animation are mainly : location and shape in time, evolution of speed, evolution of acceleration. These are the vocabulary of "cinematics".

• "Cinematics" work at the phenomenological level. Dynamic simulations generate cinematic evolutions. Then "Dynamics" work at an higher "generic" level.

We can say also : Dynamic Models are Generic Models of Motion" and "Cinematic Models are descriptive Models of motion.

The underlying notion of Dynamics is the notion of EMERGENCE. With Dynamics, that is a process to represent and simulate a possible of the phenomenon you want, You cannot obtain exactly what you have decided phenomenologically. You try to create conditions to obtain the sensorial and cognitive category of the phenomena you want.

Because of this, I think and I would like to argue and prove that "this vocabulary of Dynamics" could be the vocabulary of "Dynamic Arts".

*That are the theoretical basis of my work.*

Now I will show you a video presenting some results of our research and some uses or these results in artistic works.

All the images and motion you will see are produced by dynamically-based simulations with the software we have developped called MIMESIS.

The first sequences illustrate simulation of dynamic behavior of virtual objets.

**Video**

My name is Annie Luciani.

I am working in Grenoble at the ACROE Research Group. I founded this group in 1976 with two colleagues : Jean-Loup Florens and Claude Cadoz.

The aim of ACROE is to design and developp new concepts and technologies for Computer and Arts.

The Arts we are interested in are what we call "Temporal Arts or Dynamic Arts", specifically Music, Visual Motion or Animation, and Dance.

In this context, my work is mainly devoted to Visual Arts, Animation, in a strongest relationship with Dance and Music.

I will try to present here the technology I have developped and the philosophy which underlies this technology in Visual Arts.

My basic opinion is that the age which begins will be the "Age of Time", that means the Age of "the Science and Arts of the Time", after the age of Ratio and the age of the Equilibrium.

So, Science and Arts developped by the Greec Civilization, are based on Geometrical Concepts such as for example the Thales Theorem of Proportionnality. The Underlying Philosophy was a philosophy of "Ratios", and this philosophy Gave the Music of harmony, Harmony thought as ratios, Or the geometric ratios in space, well represented by the "Golden Number". Several Centuries after, the Newton's Mathematics opened a period in which the central concept was the notion of Equilibrium.

The period opened now is not only the age of "Information" as many people say. But, for me, more fundamentally the age of dynamic concepts : irreversibility, structured chaos, arrow of the time ...

In Music, new temporal organizations are experimented to day : opened compositions, undeterministic evolutions, free events, bifurcations ...

In Visual Arts, the Concept of Automata developped by the mechanicist Vaucanson, widely used today by several cinetic artists and the developpement of the cinema are only the beginning of what it can became a new visual art. Which will be truly a Dynamic Visual Art.

Since a long time, we are looking forward a genetic art of visual motion. For example, Futurist Italian Painters try to experiment elementary concepts in this direction.

But Photography, Cinema, mechanical automata, Video Were not sufficient to satisfy this desire.

I think that Computer and Contemporary Concepts and Technologies ARE The Tools from which this Art could be born, arise.

FurtherMore, I imagine that the new concepts which would arise in the context of these Contemporary Techonologies and under the lighting of new knowledge and Models, could be similar for all the Temporal Arts.

After this too utopic introduction, I will come back, for a short time on the technical field of Animation.

Perhaps you know how Conventional animation, with or without computer, is working.

There are two main technics :

• the first one designs motion by giving 2D or 3D Key-Frames and by interpolating the motion between them.

• the second one consists of applying time-evolution functions onto some specific parameters of 2D or 3D static objects : positions, sizes, shapes, colors ....

In both cases, the underlying assumption, "the spirit of animation", lies in the association between an explicite temporal evolution and a still life object.

Even if this "way of thinking", seems to be natural at a first glance, it is technically and philosophically inadequate to design complex relevant motions.

In fact, in most cases, it is not possible to separate a shape and its motion : For example, it is not possible to apply a gait of a light or small person to an other person who would be heavy and tall. It is no longer possible to separate different cinetic contributions inside one motion : for exemple to separate the cinematic of the displacement and of the deformation in the motion of a drop of water.

In fact, Such as a bad actor who gets to reproduce the phenomenology of behaviour, Conventional Animation methods, either with cinema or with computer, work at the phenomenological level and they try to reproduce movements. They are not methods to understand, design and create visual dynamics phenomena.

Instead of the bad actor, an excellent actor will choose another way to perform a desire or a given behaviour : he will simulate (that means "do like") a potential, a virtual, cause of the behavior he wants to create. If needed, He is able to mentally change his own body to adopt the behaviour of another thing to perform the wnated behaviour.

Then, instead of the concept of animation, I have introduced here the concept of simulation, considered in its ethymological meaning.

Now, I would like discuss briefly on two delicate points which are fundations of my work :

This virtual flag seems quite realistic but here the designer can design the fabric he wants, the wind he wants, the nature of the breaks he wants and the nature of the falling and of the collisions with the ground. This sequence has been use as a metaphor in a choregraphic composition.

The grace of this virtual puppet occurs from its physical constitution : its light weight, its deformability and from the fact that it is manipulated by feet by a human marionnettist.

The matter of these simple objects does not exist in reality. It is a paradoxal matter, which seems too light, very hard and very elastic : a sort of superball. The friction with the ground exist but its value has been chosen exactly null, which is not possible in reality.

You see here some different matters. It is possible with computer to synthesize sounds and images but also to synthesize the matter itself, which allows us to obtain best behaviour defined in a more intuitive and empiric manner.

These images have been used in a choregraphic work. We different dynamic of stretching based on the modification of the viscosity of a surface of fluid. Here I simulate a very volatile fluid and after I transformed continuously this fluid in a very viscous deformation, a kind of viscous breathing.

The second one shows a "singing rain". It is not a real rain. Only a physically-based model of the minimal elements needed to evoke a sensorial and cognitive rain. These minimal elements have been the fluidity of the propagation in space conveyed by the image and the accuracy of the non-resopnnat percussion conveyed by the sound. Then, a sensorial and cognitive rain" emerges of that minimal conditions, more realistic than a real rain.

**Stop the Video Please**

In the introduction of this talk, I spoke about complex dynamics. I would like to show now two main categories of complex dynamics, which are non-linear structured figures of Chaos : dynamic of granular material behaviors, of collective phenomena, of turbulence.

A deeply interesting dynamic organization occurs when we put together a lot of similar elements under certains dynamical conditions.

We can call these elements "grains", "atomes", "people" ... Specific dynamic phenomena emerge, which appear in granular material such as dunes or sand as well as in human crowds.

**Video**

As you see in these dynamical simulations, these main phenomena are : piling or constitution of solid communities, surface avalanches or chaos on the frontiers, emergence of sub-solid pilings, internal collapses by sub-solid sliding...

The main effect is that the figure grows by structured chaotic destruction of its contours and of its interior.

Esquisses

The last sequence has been used in an artistic work. The idea is that Dunes have very strong effects on human beings because they convey simultaneously serenity (with their smoothness and fluidity) and danger (with their brutal changing in states). You see here the fluidity and here the cut-clearly landslide.

**Stop the Video Please**

From these examples, I perform a work, in which I try to interprete graphical entities in terms of physically-based parameters of dynamic phenomena.

The following sequences show three completely different effects produced by a same dynamic model and only by changing simple physical parameters: the ration between elasticity and viscosity. These effects are the effets of piling in granular materials, the effetcs of circumvolutions in pastes and the effect of vorticity in fluids.

As you see before, the piling of granular material grows according to lineic motions. At the opposite, a fluid turbulence grows according to rotational movement. Between both, piled circumvolutions are occuring in pastes.

Then It is possible to associate the geometrical translation to the elasticity, which is the central parameter of sand effect and the geometrical rotation to the viscosity which is the main parameter to regulate the fluid turbulence.

**Stop the Video Please**

The second main dynamic visual effect is related to the transition from laminar motion to vorticity and turbulence.

This first sequence illustrates the birth of turbulence.

The motion begins with a perfect and pure lineïc and regular structure. Only after I introduced an impurity in the flowing, the motion changes from pure translation in pure rotation and then the pile grows in rotation.

After the dynamic model has been found, We can explore all the spatio-temporal shapes it can produce. Such as in the following sequence.

What I would like to say here, is that it is not a copy of nature but a dynamic model of spatio-temporal shapes which are relevant for our perception and cognition and aesthetic desire.

This last sequence has been used in one of our artistic work (Vent - Esquisses).

**Stop the Video Please**

In following sequences, I produced a dynamic figures of turbulence and after I represent visually theses figures by a specific process od visualisation which is also dynamic process.

Borges

Here there is the original. here is an interpretation of this original. I put the original flows onto a deformable surface. It acts on this deformable surface and deforms it. Then the final motion is the association of two dynamics : the dynamics of the first fluid flowings and the dynamics of the deformation of the surface.

Lamia

It is the same here. Firtly, the original. And after some dynamical interpretations of this original.

Bargar

It is the same here

**Stop the video Please**

And here the explanation of the process. The dynamic process of visualisation I just spoke is in fact a simulation of the engraving.

The surface is a dynamic surface for which I can determine the physical parameters : stiffness or rigidity, viscosity, resistance to deformation... and so on ...

With these parameters I can regulate some dynamical effects such as dynamic remanence, dynamic deep of carving, ...

Then I have a generic physical medium on which any dynamic objects can act on, engraving their trace and their history.

I can draw on a kind of sand, a kind of water or any kind of permanent or non-permanent matter.

Here you see, the fluid flow I showed previoulsy, engraving a surface of sand.

And Here another dynamic system, composed of two linked balls, engraving a non-remanent surface.

**That's all !!!!!**

There is no water on Mars But I dream that there is probably the First Degree of Music.